Infrared Spectroscopy of Adsorbed Species on the Surface of Transition Metal Oxides

A. A. DAVYDOV

Edited by C. H. Rochester

JOHN WILEY & SONS Chichester · New York · Brisbane · Toronto · Singapore

Contents

1

Preface	•••	• •	•••	•	•••	•	•••	•	•	•	•	•	• •	•	•	•	xi
Symbols a	nd al	bbrevia	ations		•••	•	•••	•	•	•	•	•	•	•	•	•	xiii
Introductio	n	•••	•••	• •	•	•	•••	•	•	•	•		•	•	•	•	1
Chapter 1.	Nat	ure of	oxide	surf	ace	cent	res			•			•				6
	1.1.	Spect	ra of o	oxid	e su	rface	es	•					•				7
		1.1.1.	Vibra	tion	is o	f m	etal-	-0	xyg	gen	bo	onds	6 0	n c	oxid	le	
			surfac	ces			• •										8
		1.1.2.	Mole	cula	r foi	ms	of a	dso	rbe	d o	xyg	gen					19
		1.1.3.	Surfa	ce h	ydro	oxyl	grou	ups									24
	1.2.	Estab	olishme	ent o	of th	e na	ture	of	sur	face	e ce	entr	es a	nd	the	ir	
		chem	ical p	rope	ertie	s us	sing	the	e a	dsc	orpi	tion	of	si	mp	le	
		mole	cules	• •	•												26
		1.2.1.	Adso	rptio	on o	f an	nmor	nia			•						27
			1.2.1.	1. L	ewis	ac	id o	ent	res	(c	001	din	ativ	ely	u	n-	
				Sa	atura	ated	met	al c	ati	ons	at	the	su	rfac	e)		28
			1.2.1.	2. B	røns	sted	acid	cei	ntre	es							33
		1.2.2.	Adso	rptio	on o	f cai	rbon	m	ono	oxid	e						37
			1.2.2.	1. S	pect	ral	ide	ntifi	icat	ion		of	car	bor	nate)—	
				C	arbo	xyla	te c	omj	pou	ind	s		•				38
			1.2.2.	2. R	eact	ivity	of v	оху	gen	ı or	1 02	xide	su	rfac	es		39
			1.2.2.	3. Iı	ntera	ictic	n of	f CO	Оv	vitł	i si	ırfa	ce ł	iydi	rox	yl	
				g	roup)S											46
			1.2.2.	4. Ī1	ntera	actic	on of	f CO	Ŋм	vith	su	rfac	e ca	atio	ns		48
		1.2.3.	Adso	rptio	on o	f Ni	tric	oxi	de								53
	1.3.	Conc	lusion	-					•								56
		Refer	ences														58

viii

	ix
3.4. Surface alkene compounds on oxide catalysts	151
3.4.1. Alumina	151
3.4.2. Titanium dioxide	152
3.4.3. Vanadium-containing catalysts	153
3.4.4. Cr_2O_3 , MnO_2 , Co_3O_4 , NiO and Fe_2O_3 .	154
3.4.5. Copper-containing catalysts	157
3.4.6. Zinc oxide	160
3.4.7. Multi-component oxide catalysts	162
3.5. Conclusion	166
References	168
Chapter 4. Application of infrared spectroscopy to mechanistic studies of heterogeneous catalytic reactions	174
4.1. Reaction mechanisms involving carbon monoxide .	175
4.1.1. Oxidation of carbon monoxide	175
4.1.2. The water-gas shift reaction	182
4.1.3. Reduction of NO with carbon monoxide	189
4.2. Reaction mechanisms involving alkenes	195
4.3. Mechanisms for the oxidation of oxygen-containing	
organic compounds	209
4.3.1. Oxidation of acrolein	209
4.3.2. Oxidation of methanol	214
$4.4. Conclusion \qquad \dots \qquad $	226
References	230
Index	237